WHAT IS CLAIMED IS:

1. A ventricular assist device for pumping blood between an inlet and an outlet, said device comprising:

an implantable frame;

a pair of compressible chambers disposed within said frame, said pair of compressible chambers including a first chamber connected to the inlet and a second chamber connected to the outlet;

an actuator disposed between said pair of compressible chambers and movable therebetween, where the movement of said actuator increases the volume of one of said pair of compressible chambers and decreases the volume of the other of said pair of compressible chambers;

a one-way valve for providing fluid communication from said first chamber to said second chamber; and

a drive unit adapted to alternately move said actuator towards one or the other of said pair of compressible chambers,

wherein the movement of said actuator towards said first chamber is a transfer stroke that transfers said blood within said first chamber to said second chamber, and

wherein the movement of said actuator towards said second chamber is a pump stroke that fills said first chamber from said inlet and empties said second chamber into said outlet.

2. The ventricular assist device of claim 1, wherein said one-way valve is a first one-way valve and further including a second one-way valve at the outlet of said second chamber to provide fluid communication from said second chamber to said outlet.

3. The ventricular assist device of claim 1, wherein said one-way valve is disposed within said actuator.

4. The ventricular assist device of claim 1,

wherein said frame includes a soft magnetic material;

wherein said actuator has an axis and includes a magnetic core about said axis and one or more magnets each having a pair of magnetic poles, a first pole and a second pole, oriented perpendicular to said axis with each of said first magnetic poles oriented either towards or away from said axis, and

wherein said drive unit includes an electromagnetic drive including one or more coils disposed within said frame and an armature coupled to said actuator, wherein said electromagnetic drive, when energized, providing a force on said armature towards one or the other of said compressible chambers according to the magnetic interaction of said soft magnetic material, said one or more magnets, and the energization of said one or more coils.

5. The ventricular assist device of claim 4, wherein said actuator includes said armature.

6. The ventricular assist device of claim 4, said drive unit further including an energy storage element having one or more springs positioned between said frame and said armature to exert a spring force on said armature;

wherein said one or more magnets generate a magnet force on said armature resulting from the attraction of said one or more magnets to said frame when said one or more coils is not electrically energized,

wherein said one or more energized coils generates a coil force on said armature that is approximately independent of the position of said armature along said polar axis and that varies according to the degree of energization of said one or more coils.

7. The ventricular assist device of claim 6, wherein the sum of said spring force, said magnet force, and said coil force is approximately independent of the position of said armature

along said polar axis, and varies according to the degree of energization of said one or more coils.

8. The ventricular assist device of claim 4,

wherein one or more pairs of gaps are defined between the armature and each one of said one or more pairs of poles, and

wherein the coil flux follows a path that contains therewithin said frame, said one or more pairs of poles, said one or more pairs of gaps, and said armature, and where each said magnet is substantially free of the coil flux.

9. The ventricular assist device of claim 8, wherein the coil flux follows a path including said frame, one pole of said one or more pair of poles, one gap of said one or more pair of gaps, said armature, another gap of said one or more pair of gaps, another pole of said one or more pair of poles, and said frame; and where each said magnet is substantially free of the coil flux.

10. A ventricular assist device for pumping blood between an inlet and an outlet, said device comprising:

a pair of compressible chambers including a first chamber with a first volume and a second chamber with a second volume, where said first volume and said second volume are variable, and where the sum of said first volume and said second volume are approximately constant;

an actuator disposed between said pair of compressible chambers and movable to change said first and second volumes,

a drive unit for moving said actuator; and

a one-way valve for providing fluid communication from said first chamber to said second chamber,

wherein the movement of said actuator towards said first chamber decreases said first volume and is a transfer stroke that transfers said blood within said first chamber to said second chamber, and

wherein the movement of said actuator towards said second chamber decreases said second volume and is a pump stroke that fills said first chamber from said inlet and empties said second chamber into said outlet.

11. The ventricular assist device of claim 10, wherein said one-way valve is disposed in said actuator.

12. The ventricular assist device of claim 10, wherein said one-way valve is a first one-way valve, and further comprising a second one-way valve at the outlet of said second chamber to provide fluid communication from said second chamber to said outlet.

13. The ventricular assist device of claim 12, further including:

a frame substantially surrounding said pair of compressible chambers and including a soft magnetic material;

wherein said actuator comprises a magnetic core and one or more magnets;

wherein said drive unit is an electromagnetic drive including one or more coils disposed within said frame that, when electrically energized, each generates a magnetic flux defining a pair of poles having an axis; and

an armature coupled to said actuator, said one or more magnets having poles oriented perpendicular to said axis with like oriented pole aligned towards said axis,

wherein said movement of said actuator moves said core along said axis, and

wherein said electromagnetic drive provides a force on said armature towards one or the other of said compressible chambers according to the magnetic interaction of said soft

magnetic material, said one or more magnets, and the energization of said one or more coils.

14. The ventricular assist device of claim 13, said drive unit further including an energy storage element including one or more springs positioned between said frame and said armature so as to exert a spring force on said armature;

wherein said one or more magnets generate a magnet force on said armature resulting from the attraction of said magnet to said frame when said one or more coils are not electrically energized,

wherein the sum of said spring forces and said magnetic force is a net bias force that is approximately independent of the position of said armature along said polar axis and biases said armature towards one of said pair of poles,

wherein said energized coils generate a coil force on said armature that is approximately independent of the position of said armature along said polar axis and that varies according to the degree of energization of said coils.

15. A biventricular assist device comprising two ventricular assist devices of claim 1.

16. A biventricular assist device comprising two ventricular assist devices of claim 10.

17. A ventricular assist device for pumping blood between an inlet and an outlet, said device comprising:

a frame formed from a soft magnetic material;

a pair of compressible chambers disposed in said frame, where said pair of compressible chambers includes a first chamber connected to the inlet and a second chamber connected to the outlet;

an actuator disposed between said pair of compressible chambers and movable therebetween, where the movement of said actuator increases the volume of one of said pair of compressible chambers and decreases the volume of the other of said pair of compressible chambers;

a first one-way valve for providing fluid communication between said pair of chambers in a direction from said first chamber to said second chamber; and

a second one-way valve at the outlet of said second chamber for providing fluid communication from said second chamber to said outlet,

an electromagnetic drive disposed within said frame; and

an energy storage element disposed between said frame and said actuator,

wherein the motion of said actuator towards said first chamber is a transfer stroke that transfers said blood within said first chamber to said second chamber, and the motion of said actuator towards said second chamber is a power stroke that fills said first chamber from said inlet and empties said second chamber into said outlet;

wherein, during said transfer stroke, electric power delivered to said electromagnetic drive is stored in said energy storage element, and

wherein, during said power stroke, electric power delivered to said electromagnetic drive and said stored energy is delivered to said actuator.

18. The ventricular assist device of claim 17, wherein said first one-way valve is disposed within said actuator.

19. The ventricular assist device of claim 17, wherein said actuator has an axis and includes a magnetic core about said axis and one or more magnets having a first and second magnetic poles oriented perpendicular to said axis with each of the first magnetic poles oriented either towards or away from said axis,

wherein said electromagnetic drive includes one or more coils disposed within said frame and an armature coupled to said actuator, and

wherein said electromagnetic drive, when energized, provides a force on said armature towards one or the other of said compressible chambers according to the magnetic interaction of said soft magnetic material, said one or more magnets, and the energization of said one or more coils.

20. The ventricular assist device of claim 19, wherein said armature is part of said actuator.

21. The ventricular assist device of claim 19, said energy storage element having one or more springs positioned between said frame and said actuator to exert a spring force on said actuator;

wherein said one or more magnets generates a magnetic force on said actuator resulting from the attraction of each said magnet to said frame when said one or more coils is not electrically energized,

wherein the sum of said spring forces and said magnetic force is a net bias force that is approximately independent of the position of said actuator along said polar axis and biases said actuator towards one of said pair of poles, and

wherein said energized coils generate a coil force on said actuator that is approximately independent of the position of said actuator along said polar axis and that varies according to the degree of energization of said coils.

22. The ventricular assist device of claim 19,

wherein one or more pairs of gaps is defined between the armature and each of said pair of poles, and

wherein the coil flux follows a path including one of said pair of poles, one of said pair of gaps, said armature, the other of said pair of gaps, and the other of said pair of poles, where the magnet is substantially free of the coil flux.

23. A biventricular assist device comprising two ventricular assist devices of claim 17.

24. An electromagnetic drive comprising:

a frame formed from a soft magnetic material;

one or more coils disposed within said frame that, when electrically energized, generate a magnetic flux and define one or more pairs of magnetic poles each having a polar axis;

an armature within said frame having a magnetic core, a non-magnetic material surrounding said core, and one or more magnets in said non-magnetic material, wherein said core is movable along said polar axis, and where the poles of said one or more magnets are oriented perpendicular to said polar axis with like oriented pole aligned towards said polar axis; and

one or more springs positioned between said frame and said armature so as to exert a spring force on said armature;

wherein said one or more magnets generate a magnet force on said armature resulting from the attraction of said magnet to said frame when said pair of coils is not electrically energized,

wherein the sum of said spring forces and said magnetic force is a net bias force that is approximately independent of the position of said armature along said polar axis and biases said armature towards one of said pair of poles, and

wherein said energized coils generate a coil force on said armature that is approximately independent of the position of said armature along said polar axis and that varies according to the degree of energization of said coils.

25. The electromagnetic drive of claim 24,

wherein one or more pair of gaps is defined between the armature and each one of said one or more pair of poles.

26. The electromagnetic drive of claim 19, wherein the coil flux follows a path including one of said one or more pair of poles, one of said one or more pair of gaps, said armature, the other of said one or more pair of gaps, and the other of said one or more pair of poles, where the magnet is substantially free of the coil flux.

27. A drive system for a pump including a first variable volume chamber, a second variable volume chamber, one or more magnets, and an actuator movably disposed between said first and second chambers, where the movement of said actuator changes the volume of said first chamber and said second chamber, said system comprising:

an electromagnetic drive including an electromagnet and an armature coupled to said actuator; and

an energy storage device that biases said actuator to decrease the volume of said second chamber, where said energy storage device stores energy from said armature when said armature moves to decrease the volume of said first chamber, and where said energy storage device delivers energy to said armature when said armature moves to decrease the volume of said second chamber.

28. A ventricular assist device comprising:

a blood pump connected to a heart and adapted to pump blood from a ventricle to the aorta;

a drive system to supply power to said pump;

a sensor that detects changes in the ventricular pressure; and

a controller triggered by an output of said sensor for actuating said blood pump,

such that said sensor triggers said controller based on the sensing of changes in the ventricular pressure.

29. The ventricular assist device of claim 28, where said controller has a programmable actuating algorithm for changing said actuating from one beat of the heart to the next beat.

30. The ventricular assist device of claim 28, wherein said pump includes an actuator plate and said triggering is based on the motion of said actuator plate due to variations in ventricular pressure.

31. The ventricular assist device of claim 30, wherein said actuator plate is between a pair of serially connected pumping chambers in said pump that operate in a two-stroke mode, specifically a power stroke and a transfer stroke, said pump including a spring bias for storing energy from a drive unit during the transfer stroke so as to reduce pump size and reduce electrical energy consumption of said pump.

32. The ventricular assist device of claim 31, wherein said pump is triggered from variations in the ventricular pressure such that said pump may execute a pump/transfer stroke sequence at more or less than the cardiac cycle.

33. The ventricular assist device of claim 28, wherein said sensor detects contractions of the left ventricular of a heart under normal heart conditions and triggers said controller.

34. A method of controlling a ventricular assist device comprising initiating said device from a sensor that detects an increase in the ventricular pressure.

35. A method of controlling a ventricular assist device having at least one valve and an electromagnetically driven pump comprising driving said pump to minimize the force on at least one of said at least one valve.

36. A biventricular assist device comprising:

an electromagnetic drive including one or more coils disposed within a frame that, when electrically energized, generate a magnetic flux and define one or more pairs of magnetic poles each having a polar axis; and an armature having an axis and includes a magnetic core about said axis, one or more magnets having first and second magnetic poles oriented perpendicular to said axis with each of the first magnetic poles oriented either towards or away from said axis,

a pair of compressible chambers, each adapted to pump one of the right and left ventricle according to the action of said electromagnetic drive; and

an energy storage element adapted to store and release energy from said electromagnetic drive and said pair of compressible chambers,

wherein, during a stroke to pump the right ventricle, electric power delivered to said electromagnetic drive is stored in said energy storage element, and

wherein, during a stroke to pump the left ventricle, electric power delivered to said electromagnetic drive and said stored energy is delivered to said armature; and

wherein said electromagnetic drive, when energized, provides a force on said armature towards one or the other of said compressible chambers according to the magnetic interaction of said frame, said one or more magnets, and the energization of said one or more coils.

37. A ventricular assist device comprising:

a pair of compressible chambers connected in series, where said pair of compressible chambers includes a first chamber connected to the device inlet and a second chamber connected to the device outlet;

an armature movable to contract one of said pair of chambers and expand the other of said pair of chambers;

at least one, one-way valve providing fluid communication between said pair of chambers in a direction from said first chamber to said second chamber, where the motion of said armature towards said first chamber is a transfer stroke that transfers blood within said first chamber to said second chamber, and where the motion of said armature towards said second chamber is a power stroke that fills said first chamber from said inlet and empties said second chamber into said outlet;

an electromagnetic drive; and

an energy storage element coupled to said armature,

wherein, during said transfer stroke, electric power delivered to said electromagnetic drive is stored in said energy storage element, and

wherein, during said power stroke, electric power delivered to said electromagnetic drive and said stored energy is delivered to said armature.

38. A method of pumping blood with a ventricular assist device using a pump having two variable volume chambers including a first chamber to accept said blood at a pump inlet, a second chamber to expel said blood at a pump outlet, and a one-way valve between said first chamber and said second chamber to allow blood to flow from said first chamber to said second chamber, said method comprising:

simultaneously increasing the volume of said first chamber and decreasing the volume of said second chamber with said one-way valve closed during a pump stroke;

rapidly terminating said pump stroke such that the momentum of blood in the inflow conduit and outflow conduit and pump causes said one-way valve to open, such that the volume of blood discharged during said pump stroke is greater than the change in volume of said second chamber during said pump stroke.

39. The method of claim 38, wherein said one-way valve is a first one-way valve and said ventricular assist device further includes a second one-way valve at the outlet of said second chamber to provide fluid communication from said second chamber to said outlet.

40. The method of claim 38, wherein said pump has an active filling capability such that said pump can maintain a minimum level of circulation under abnormal heart conditions.